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Vegetable Crops -- 1985: A Summary of Research

The Ohio State University
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ON THE COVER: Dr. Stanley F. Gorski, associate professor of horticulture, examines the root system of onions treated with an experimental herbicide. Onion research is conducted at the OARDC Muck Crops Branch, Celeryville.

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Eggplant and Tomato: A Study on the Effects of Transplant Root Volume on Yield

S. F. GORSKI and M. K. WERTZ[1]

ABSTRACT

Transplant container size effectively increased yield of eggplant (*Solanum melongena* L.) and tomato (*Lycopersicon esculentum* Mill.) As container size increased, a significant linear increase in eggplant early [$y = 7.46 + 0.021\ (x - 120.3)$, $r^2 = 0.80$] and total [$y = 35.7 + 0.049\ (x - 120.3)$, $r^2 = 0.59$] fruit yields and tomato early [$y = 74.63 + 0.143\ (x - 120.3)$, $r^2 = 0.85$] fruit yields occurred.

INTRODUCTION

Earlier and larger yields of vegetables result when using transplants rather than direct seeding in the field (2, 4, 7). Transplant size affects premature heading of broccoli (*Brassica oleracea* L. var. *italica*) (1) and may be a factor in buttoning of cauliflower (*Brassica oleracea* L. var. *botrytis*) (3). In cabbage (*Brassica oleracea* L. var. *capitata*), where container size and transplant age were uniform, larger sized seedlings produced larger heads and higher yields (6). Increases in container size and transplant age increased lettuce (*Latuca sativa* L.) yield (9). In Chinese cabbage (*Brassica rapa* L.), yields from transplants grown in 7.5 cm containers were significantly greater than those in 2.5 cm containers, and the higher yields compensated for the increased cost of raising the larger seedlings (5).

The purpose of this study was to evaluate the effects of various root volumes of tomato and eggplant transplants on fruit yields.

MATERIALS AND METHODS

Root volume studies on 'Classic' eggplant and 'Freedom' tomato were conducted during 1981 and 1982. Container sizes consisted of Speedling 100A,[2] 96, 72, 48, 32, and 18-count cell pak trays (Table 1). Seeding dates were staggered to produce transplants where the rooting medium was filled with roots but not to the point of being rootbound. Seeding dates were established from a similar study the previous year and were: 18-count cell pak trays on March 26; 32, 48, and 72-count trays on April 7; and the 96-count trays and Speedling 100A on April 14. Container transplant dates followed 1 week from seeding dates, and field setting for all plants was in late May.

Experiments were arranged in a randomized complete block design with 4 replications of 17 plants per treatment. Plants were spaced on 46 cm centers in 7.6 m long rows. Recommended cultural practices were followed.

Harvesting of each crop was begun in late July of each year. Early yield data consist of the first three harvests. Total yield data were collected for the entire

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TABLE 1.—Container Type, Root Volume, and Wholesale Cost per Plant.

Container Type	Container Dimensions (cm)	Root Volume per Plant (cm^3)	Wholesale Cost per Plant in 1982 (cents/plant)
Speedling 100A	2.5 x 2.5 top 1 x 1 base 7.5 high	27	1.8
96 count cell pak	4 x 3 top 2.5 x 1.5 base 6 high	47	3.6
72 count cell pak	4 x 4 top 2.5 x 2.5 base 6 high	67	4.9
48 count cell pak	6 x 4 top 4.5 x 2.5 base 6 high	106	7.3
32 count cell pak	6 x 6 top 4 x 4 base 6 high	156	10.9
18 count cell pak 6	8 x 8 top 6.5 x 6.5 base high	319	19.4

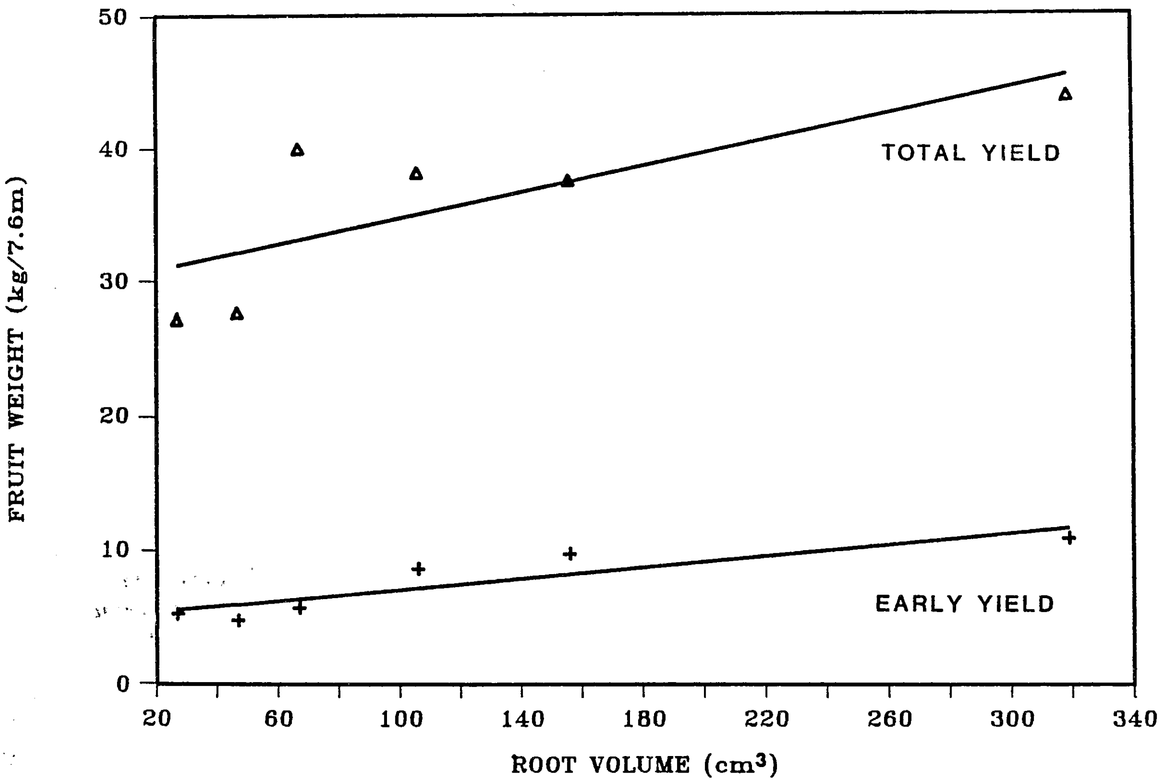

FIG. 1.—Eggplant response to increasing transplant container root volumes. Significant linear increase for both early [$y = 7.46 + 0.021 (x - 120.3)$, $r^2 = 0.80$, lsmeans = +] and total [$y = 35.7 + 0.049 (x - 120.3)$, $r^2 = 0.59$, lsmeans = Δ] yields.

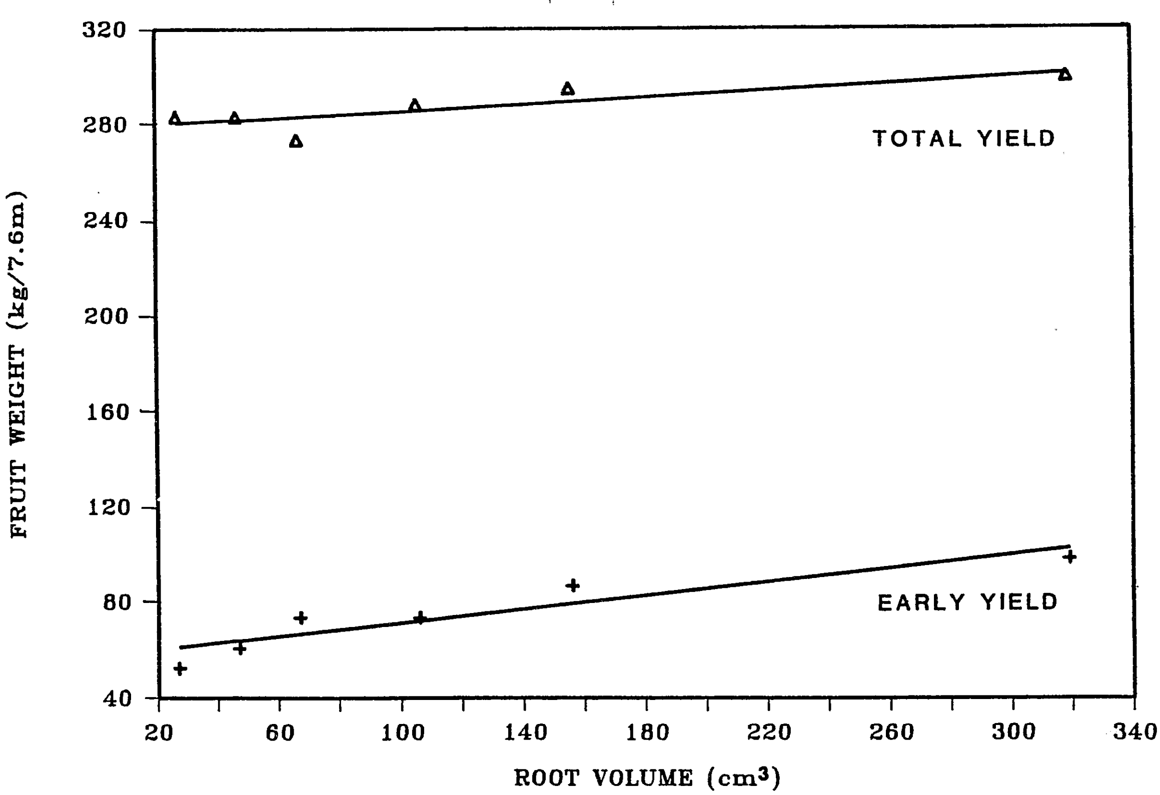

FIG. 2.—Tomato response to increasing transplant container root volumes. Significant linear increase for early [$y = 74.63 + 0.143 (x - 120.3)$, $r^2 = 0.85$, lsmeans = +]. Non-significant response for total yield (lsmeans = Δ).

season. Harvests were made approximately once a week for the duration of the harvest season. Data were subjected to analysis of variance and least squares means polynomial fitting.

RESULTS AND DISCUSSION

Data for both years were similar and therefore combined. Increasing root volume had a significant linear effect on eggplant yield (Fig. 1). Early yield [$y=7.46 + 0.021\ (x-120.3)$, $r^2=0.80$] increased from a low of 5.5 kg/7.6 m to a high of 11.6 kg as container size increased from 27 to 319 cm^3, respectively. This represents a 111% increase in fruit weight. Total yield [$y=35.7 + 0.049\ (x-120.3)$, $r^2=0.59$] also increased with increasing container root volume. Fruit weight increased from 31.1 kg (27 cm^3) to 45.4 kg (319 cm^3), which represents a 46% increase.

Early tomato yields were also significantly affected by increasing container root volume (Fig. 2). Early yield (kg/7.6 m) [$y=74.63+0.143\ (x-120.3)$, $r^2=0.85$] increased from 61.3 kg (27 cm^3) to a high of 103 kg (319 cm^3). This represents a 68% increase in fruit yield. Tomato total yield increased approximately 20 kg from the smallest container root volume to the largest. However, this was not a significant difference ($P \leq 0.05$). One reason for this lack of significance for total yield might be the length of the growing season. The larger plants (greater root volume) produced a heavier fruit set earlier in the season than the smaller transplants. Early fruit set was at the expense of subsequent vegetative growth. The smaller plants were capable of increased vegetative growth due to their smaller fruit set. This enabled them to obtain a size and total fruit yield similar to the larger sized transplants.

The cost of transplants varies considerably from Speedling 100A (1.8¢) to the 18-cell count cell pak (19.4¢). Results of this study suggest that the larger sized transplants outproduce the smaller sizes during the entire growing season for eggplant and during early season tomato production. Production costs as well as market value of the crop must be considered before selecting a transplant size. It is possible that the increased early yields (when market value is generally higher) may be more than enough to pay for the higher costs of larger transplants.

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Lettuce and Endive Cultivar Tolerance to Thiobencarb

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ABSTRACT

Thiobencarb (S [4-chlorophenyl methyl] diethylcarbamethioate) effectively decreased weed populations in lettuce (*Lactuca sativa* L.). As rates of thiobencarb increased, a significant linear decline ($r^2 = 0.75$) in weed population occurred. 'Summer Bibb' and 'Dark Green Boston' lettuce and 'Salad King' endive (*Cichorium endivia* L.) exhibited acceptable tolerance to thiobencarb at rates up to 6.7 kg/ha. Tolerances to thiobencarb were established at 3.0 to 4.0 kg/ha for 'Summer Bibb' and 3.0 kg/ha for 'Dark Green Boston' cultivars. An optimum rate for 'Salad King' was not established since there was no decline in fresh weight. 'Florida Deep Heart' escarole and 'Valmaine' and 'Slow Bolt' lettuce cultivars were not susceptible to the rates of thiobencarb tested.

INTRODUCTION

Thiobencarb, a thiocarbamate herbicide used for the control of annual grasses in rice (6), has been investigated for use on muck-grown celery (3) and lettuce (4). It provided 90% or better control of broadleaf weed species and 80% or better control of the grass weed species present with acceptable crop safety (3). Results of these studies indicated differential varietal tolerance to thiobencarb. Other vegetable crops have been reported to vary in their susceptibility to herbicides (9, 10).

Soil type and environmental conditions have been shown to affect the activity of thiocarbamate herbicides (1, 2, 4, 7, 8). Soil and environmental conditions in Ohio are different from those where previously reported work has been conducted. For this reason, studies were carried out under Ohio conditions. The differential cultivar responses to thiobencarb, as well as weed control, were investigated in this study to provide a greater understanding of individual lettuce and endive cultivar responses to thiobencarb on muck soils.

MATERIALS AND METHODS

Four lettuce cultivars, 'Valmaine', 'Summer Bibb', 'Dark Green Boston', and 'Slow Bolt', and two endive cultivars, 'Salad King' and 'Florida Deep Heart', were seeded at the OARDC Muck Crops Branch near Celeryville. The soil was a Carlisle muck containing 75% organic matter with a pH of 5.3.

Treatments consisted of thiobencarb applied preemergence at rates of 0, 2.2, 3.4, 4.5, and 6.7 kg/ha. Three rows of each cultivar were seeded 40 cm apart on 1.5 m wide beds 5.5 m long. Experimental design was a randomized complete block with four replications. Herbicide applications were made using a tractor drawn sprayer delivering 393 liters/ha at a pressure of 2.11 kg/cm^2. As weeds germinated, they were cultivated out. At maturity, the crops were harvested and fresh weights recorded.

In a companion study, weed control was determined using the 'Summer Bibb' lettuce cultivar. Treatment rates were 0, 2.2, 4.5, and 6.7 kg/ha of thiobencarb. All other methods were similar to the first study. Weed control was determined by counting the number of weeds in a 0.093 m^2 ring 30 days after herbicide treatment. Two counts were made for each replicate. In this study, plots were not cultivated until after weed counts were made. Data were subjected to analysis of variance and least squares means polynomial fitting (5).

RESULTS AND DISCUSSION

Weed species and populations were: fall panicum (*Panicum dichotomiflorum* Michx.) 77%, and large crabgrass [*Digitaria sanguinalis* (L.) Scop.] 23% for the annual grasses; and common purslane (*Portulaca oleracea* L.) 59%, redroot pigweed (*Amaranthus retroflexus* L.) 8%, and Pennsylvania smartweed (*Polygonum pensylvanicum* L.) 32% for the broadleaf weeds. Thiobencarb applied to 'Summer Bibb' lettuce at rates to 6.7 kg/ha significantly reduced the weed population (Fig. 1). The effect of increasing rate of thiobencarb on the weed population was linear ($r^2 = 0.75$). Weed population declined from a high of 74 weeds per 0.093 m^2 to a low of 15, an 80% decline in weed population.

'Florida Deep Heart' endive exhibited no significant response to the increasing rates of applied thiobencarb (data not included). There was no major fresh weight increase or decrease even at the 6.7 kg/ha rate. Fresh weight of 'Salad King' endive exhibited a significant linear increase ($r^2 = 0.53$) with rate of thiobencarb (Fig. 2). At the 5.0 to 6.7 kg/ha rates of thiobencarb, a 15% increase in fresh weight occurred. An optimum rate of thiobencarb could not be established for endive in this experiment due to the significant positive linear relationship between rate of thiobencarb and endive fresh weight. There was no decline in endive fresh weight, even at the 6.7 kg/ha rate of applied thiobencarb. Endive expressed a strong tolerance to thiobencarb at the rates tested.

A significant quadratic response ($r^2 = 0.45$) was observed for the effect of rate of thiobencarb on 'Summer Bibb' lettuce fresh weight, signifying an optimal herbicide rate was determined (Fig. 2). At thiobencarb rates of 3.0 to 4.0 kg/ha, an approximate 10% increase (above the control) in 'Summer Bibb' fresh weight was observed. When thiobencarb rate exceeded the 3.0 to 4.0 kg/ha range, a detrimental effect on fresh weight was observed. A fresh weight decline from a high of 111% (of

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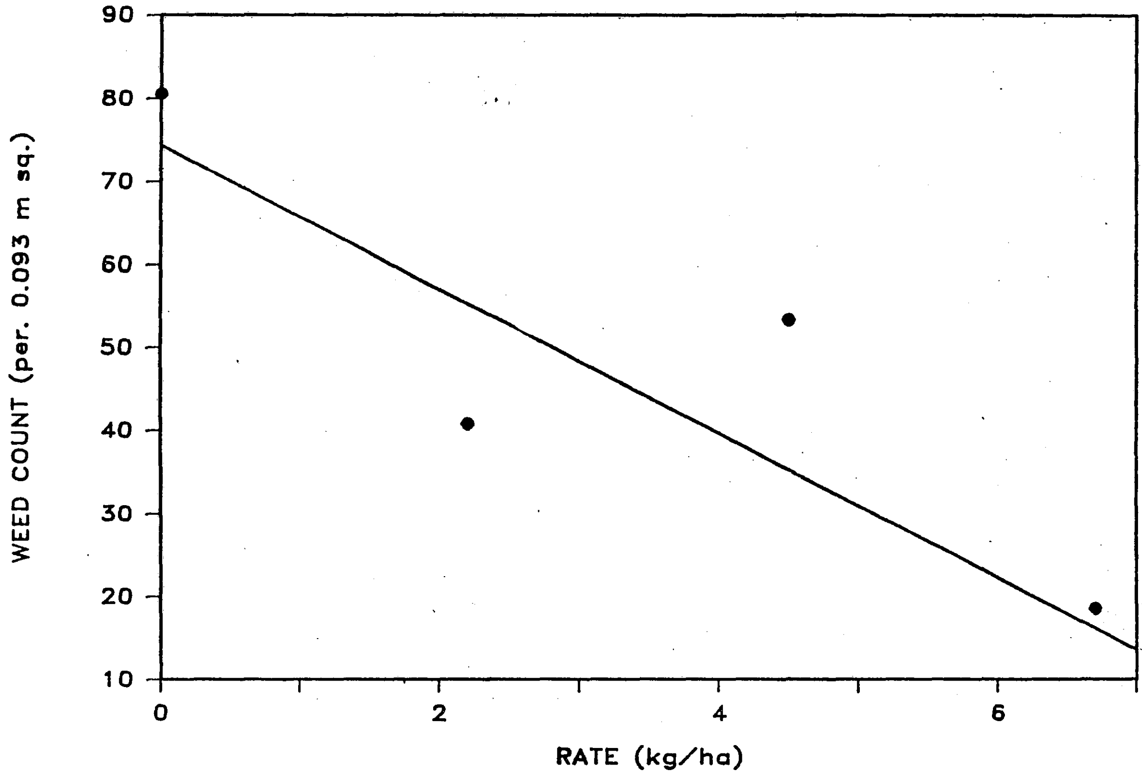

FIG. 1.—Weed response to increasing rates of thiobencarb. Significant linear [$y = 48.3 - 8.7(x - 3)$, $r^2 = 0.75$] decrease in weed population due to pre-emergence application of thiobencarb.

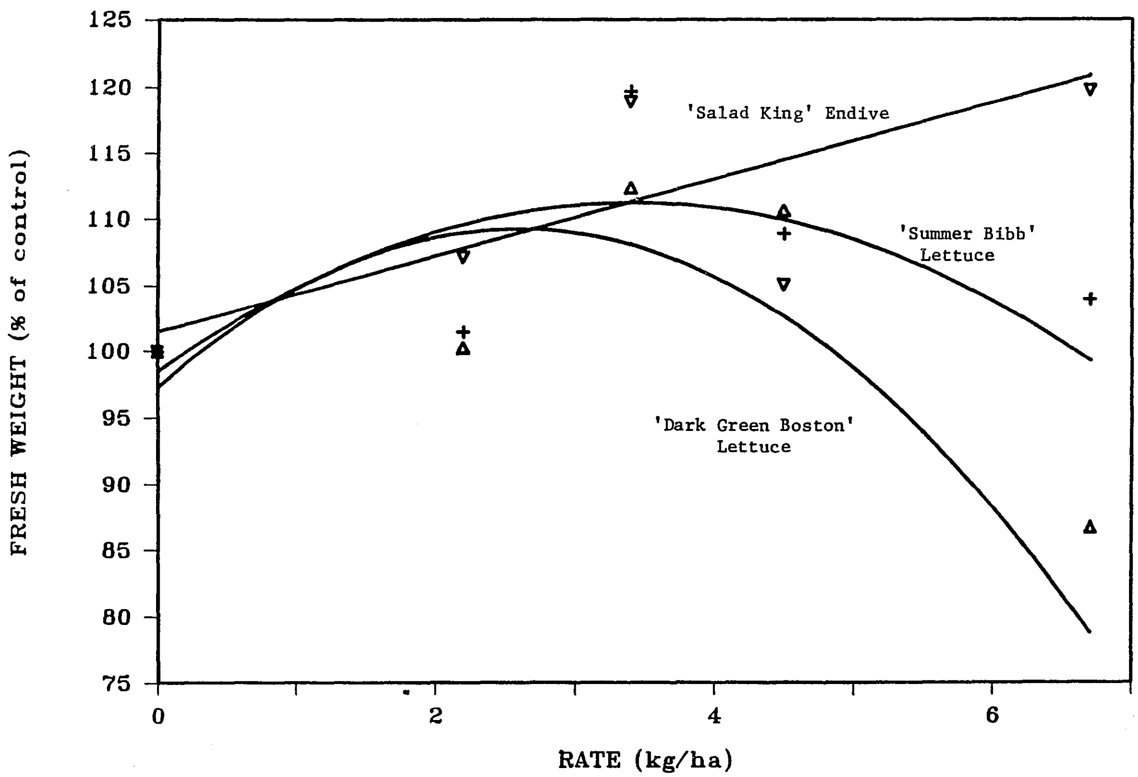

FIG. 2.—Lettuce and endive fresh weight response to thiobencarb. Regression equations and least square means (lsmeans) are $Y = 110.2 + 2.9(x - 3)$, $r^2 = 0.53$, lsmeans = Δ for 'Salad King' endive; $Y = 111.1 + 1(x - 3) - 1.1(x - 3)^2$, $r^2 = 0.45$, lsmeans = + for 'Summer Bibb' lettuce; and $Y = 109.1 - 1.5(x - 3) - 1.8(x - 3)^2$, $r^2 = 0.72$, lsmeans = Δ for 'Dark Green Boston' lettuce.

control) to 99% was observed, indicating a 12% drop in yield. An optimal thiobencarb rate range can now be established for 'Summer Bibb' lettuce.

The 'Dark Green Boston' cultivar also exhibited a significant quadratic response ($r^2 = 0.72$) to thiobencarb rate (Fig. 2). An optimal herbicide rate was established at a 2.0 to 3.0 kg/ha range of thiobencarb, where a high yield of 109% (of control) was observed. Beyond 3.0 kg/ha, a sharp decline in fresh weight occurred to a low of 79% at the 6.7 kg/ha rate of thiobencarb, a 30% decline in fresh weight. An optimum rate for 'Dark Green Boston' lettuce was established at 3.0 kg/ha.

'Valmaine' and 'Slow Bolt' lettuce cultivars exhibited no significant response to increasing rates of thiobencarb (data not included). There was neither an increase or decrease in fresh weight for either cultivar.

Results of this study indicate that lettuce and endive cultivars vary in their degree of tolerance to thiobencarb. Thiobencarb is phytotoxic to such cultivars as 'Summer Bibb' and 'Slow Bolt'. Endive cultivars appear to have more tolerance to thiobencarb than selected lettuce cultivars.

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The Effects of Clear and Black Polyethylene Mulches on the Soil Environment

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ABSTRACT

Soil temperature was significantly higher under a clear plastic mulch than black plastic. However, black plastic increased the soil temperature above that of bare soil. Black plastic was more efficient in maintaining soil moisture than clear plastic. Both plastic mulches maintained soil moisture levels above that of the bare soil. As the season progressed, the moisture content of the soil decreased. High levels of CO_2 built up under both the clear and black plastic. The CO_2 concentration was higher under the clear plastic than the black.

INTRODUCTION

A mulch is a substance applied to the soil surface to influence the soil environment in a manner which enhances growth and development of a crop. Mulches generally change the soil temperature, increase soil moisture, aid in the control of weeds, suppress insect pests and disease, and have a beneficial effect on crop yield.

The effect of mulching soil with various materials has been studied by many researchers (1, 2, 3, 6). Lyon (8) examined clear, black, and reflective polyethylene and found that at night, soil temperatures under all the mulches were similar to those of bare soil. During the daylight, however, temperatures under reflective polyethylene and in bare soil were similar and both were much lower than for clear and black polyethylene.

Other researchers have studied the effect of plastic mulching on soil moisture (1, 4, 5, 7). Mulches aid in the maintenance of soil moisture. The amount of influence they have depends on the type and color of the mulching material.

The purpose of this study was to examine soil temperature, moisture, and soil CO_2 evolution under clear and black polyethylene mulches in Ohio.

MATERIALS AND METHODS

This experiment was carried out at The Ohio State University Horticultural Farm at Columbus during the summer of 1980. The soil type was a Brookston silty clay loam with 2% O.M. A bed shaping operation was performed on the field with the resulting beds being 5 cm high, 1.2 m wide, and 7.6 m long. Napropamide [2-(α-naphthoxy)-N, N-diethyl propionamide] at 2.24 kg ai/ha was applied to the beds and incorporated to a depth of 5 cm for weed control. Clear or black plastic mulch was then laid over the beds. A third treatment of non-mulched soil was also included. The experimental design was a randomized complete block with three replicates. Eggplant (*Solanum melongena* var. *esculentum*) was planted in the field after the plastic was laid.

Soil temperature was recorded each day between the hours of 7-8 a.m. and 4-5 p.m. Thermometers were set in the eggplant row between the plants with the sensor at the 10 cm depth. Temperatures were recorded for each treatment and replicate.

Soil samples (2 cm dia. x 10 cm deep) were collected from three locations in each treatment and replicate. Samples were weighed, oven dried for 24 hours at 105° C, and then reweighed. Moisture content of the sample was then calculated. Sampling was carried out weekly.

Atmospheric gas samples were collected at the soil surface (under the plastic mulch) and at the 1 m level for 5 consecutive days in August. Gas samples were 3 cc in volume and were taken at 12-1 p.m. and again at 10-11 p.m. Three samples per treatment and replicate were drawn from the center of each row. Samples were then analyzed for their CO_2 content using a Beckman gas chromatograph.

All data were statistically analyzed using Duncan's multiple range test at the 5% level of significance.

RESULTS AND DISCUSSION

Soil temperatures were significantly warmer under the clear plastic mulch than under black plastic or on bare soil (Table 1, Fig. 1). This was true for both the 7-8 a.m. and 4-5 p.m. recording times. Soil underneath the black plastic was significantly warmer than the bare soil for the morning reading only. Afternoon readings showed no significant differences between these two treatments. It is possible that the Brookston silty clay loam soil type is dark enough to absorb solar radiation at a similar rate as black plastic, which would account for similar afternoon readings. During the cooling hours of the night, the black plastic maintained a resistant barrier to heat loss. Therefore, the plastic mulched soil would be warmer in the early morning hours. Temperature differences of the greatest magnitude occurred during the first 4 weeks of the season (Fig. 1).

TABLE 1.—Effects of Bare Soil, Clear and Black Polyethylene Mulches on Average Soil Temperatures and Moisture Content During June-September 1980.

Treatment	Soil Temperatures (°C) 7-8 a.m.	Soil Temperatures (°C) 4-5 p.m.	Percent Soil Moisture
Clear	24.2	27.1	18.96
Black	22.6	25.3	22.09
Bare Soil	21.8	25.4	17.77
LSD 5%	0.8	1.7	1.07

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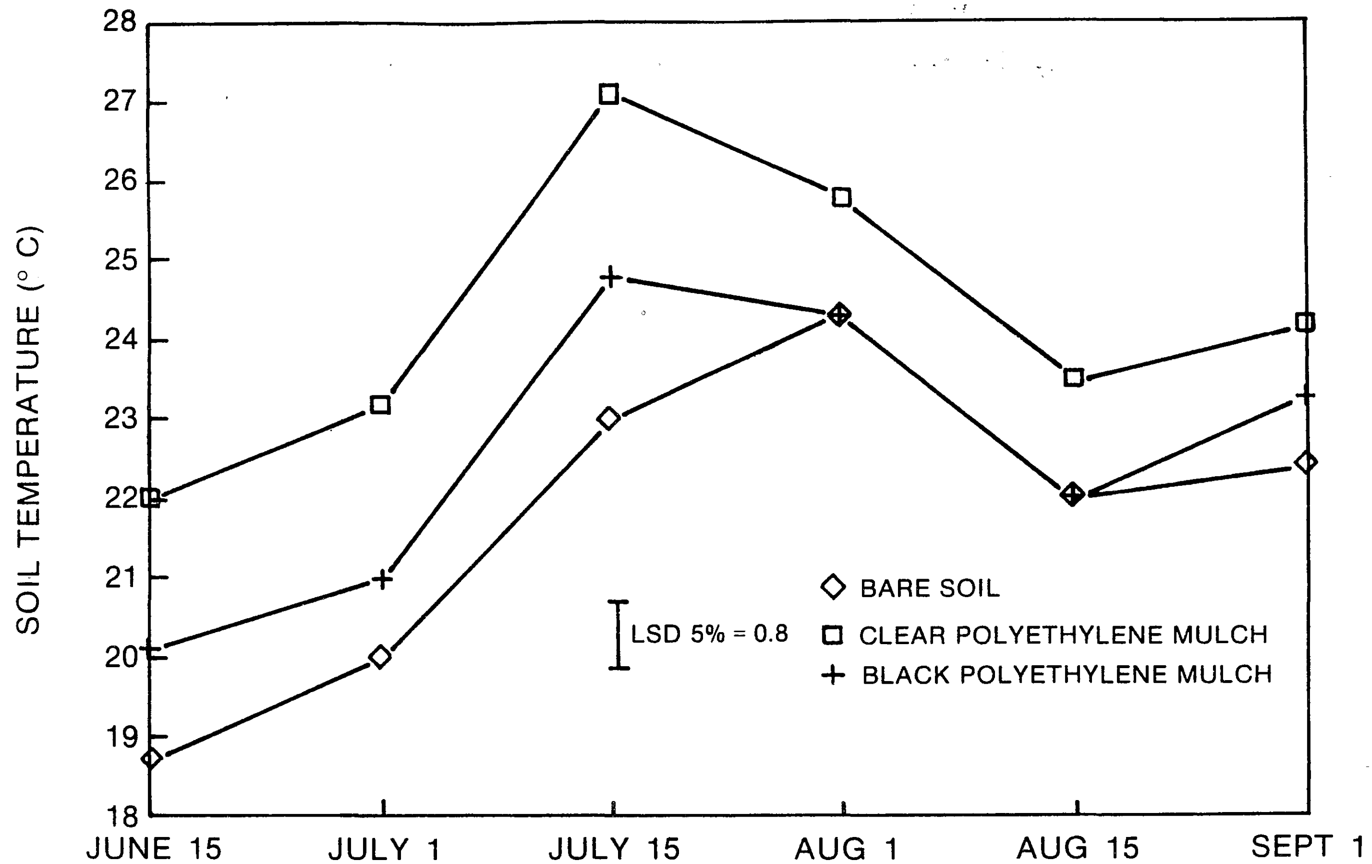

FIG. 1.—Effects of bare soil, clear and black-polyethylene mulches (1.5 mil thick) on soil temperatures. Recorded at 7-8 a.m. and at 10-cm depth.

As the season progressed, the eggplants' canopy began to shade the plastic and reduce its effectiveness.

Clear plastic was more efficient in increasing the soil temperature than black plastic or unmulched soil due to its ability to allow more radiant energy to pass through during the daytime.

Soil moisture was significantly higher under black plastic, followed by clear plastic and bare soil (Table 1). Both clear and black plastic were found to be effective in conserving soil moisture. This is a beneficial attribute for crop growth. Soil moisture fluctuated less under the plastic films than in the bare soil treatment. This fluctuation was closely associated with the amount of rainfall. Generally, as the season progressed the percent soil moisture decreased.

TABLE 2.—Effects of Clear and Black Polyethylene Mulches on CO_2 Concentration.

	CO_2 Concentration (ppm)	
Treatment	**12 Noon**	**10 p.m.**
Clear	4920.00	3975.51
Black	2584.44	2455.56
Bare Soil	353.33	393.33
LSD 5%	161.95	241.77

High concentrations of CO_2 accumulated under the plastic mulch. Carbon dioxide concentrations were significantly higher under the clear plastic mulch, followed by black and the bare soil (Table 2). These differences existed at both the noon and 10 p.m. samplings. This may be a result of the clear plastic maintaining an increased soil temperature over the other treatments. Increased soil temperature and moisture under the plastic mulches undoubtedly increased microbial activity, which could account for the increase in CO_2. The plastic mulch acts as a restrictive barrier preventing the escape of soil CO_2 (4350 cc/24 hr/645.2 cm^2 using 1.5 mil plastic) into the atmosphere. Its main avenue of escape would be through the planting holes or tears in the plastic.

Increased crop growth using plastic mulches is a multi-factor response. Increased temperature, moisture, and possibly soil CO_2 levels are partly responsible for this response.

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Evaluation of Processing Tomato Breeding Lines and Cultivars for Mechanical Harvesting and Quality in 1984: A Summary of Progress

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INTRODUCTION

Tomatoes are the most important processed crop in Ohio, with a harvested acreage in 1984 of 15,900 acres and about 387,960 tons of production, which was slightly down from 1983. Much of the acreage was set and seeded later than expected; however, conditions for harvest were in general good and the state average yield was a record 24.4 tons per acre, up from 21.4 tons per acre in 1983. New planting practices, growing methods, machine harvest-bulk handling, and new processing technology require a continuous supply of better suited varieties for the industry to be competitive with other production areas. Ohio remains by far the second largest processing tomato production state.

This breeding work continues to be directed with emphasis on improvement of the whole canned tomato (whole pack) and diced tomato product. Other needs of the canner are being given attention in relation to these products, as well as development of improved varieties for processing of juice, sauce, and paste products.

Selection for earliness and improved fruit setting ability, especially during periods of heat stress, is being carried out to reduce the problem of split fruit set and make possible more uniform harvest-delivery schedules (1, 5). With increased direct seeding, greater emphasis is being given to seed germination cold tolerance. Other important characteristics being selected to make machine harvest and bulk handling more efficient include crack resistance, firmness, and ability of ripe fruit to store well on the vine for extended periods to allow maximum usable ripe fruit recovery in once-over harvest. Thus, in addition to increased productivity, a major objective is more effective utilization of yield already being attained, especially in regard to factors minimizing losses due to overripe, rotted, and green fruit. Jointless pedicel (j2) is being utilized to facilitate machine harvest and allow delivery of fruit free of stems.

Improved quality factors being selected for and intensively evaluated in cooperation with commercial processors include: acidity, pH, soluble solids, viscosity, color (crimson fruit color [og^c] and high pigment fruit color [hp]), vitamin C, and especially fruit attributes conditioning efficient lye or steam peeling characteristics, corelessness, and high case yield.

For the 1984 season, there was a major increase in planted acreage of the early-main season Verticillium-Fusarium resistant, machine harvest cultivar Ohio 7870. It continued to exhibit excellent productivity and especially good fruit disease resistance and holding ability. Yields of Ohio 7870 were excellent in hand harvest as well as machine harvest. It exhibited good adaptability for the production of whole-canned coreless and diced product, as well as in pureed product. Reports on quality continued to be excellent. Acreage of Ohio 7870 is increasing in Ohio, as well as surrounding midwestern and eastern states where it has already become a major variety (3).

The early-main season Verticillium and Fusarium resistant variety Ohio 7681 also continues to be grown extensively and is used exclusively for processed product (2).

The acreage of Ohio 7814 increased. It is proving to be a valuable asset as an early-main season Fusarium resistant, jointless pedicel, machine harvest type with excellent firmness, holding ability, and resistance to fruit rots. It is excellent for coreless whole pack, diced pack, and pureed products. Yields and quality through the Midwest and Canada were excellent and acreage of Ohio 7814 will increase in 1985 (4).

MATERIALS AND METHODS

Location: Vegetable Crops Branch, Fremont, Ohio.

Soil: Silty clay loam, fall bedded, October 1983.

Fertilizer: 800 lb per acre of 0-26-26, Oct. 10; 108 lb per acre of 34-0-0, May 1.

Herbicide: Devrinol 1-1/2 lb ai May 26; Sencor directed spray 0.3 lb ai June 14; Amiben granular, 40 lb ai June 28.

Plants: Greenhouse-grown, 108 per standard flat from seed sown April 14.

Transplanted to Field: May 29, a two-row transplanter using 21-53-0 starter at 5 lb per 100 gal of water; 1/2 pint per plant.

Plot Size and Spacing: One-row plots, 20 plants per row spaced 12 inches, rows 5 feet apart; Trial I, four replications; Trial II, two replications.

Insect and Disease Control: Standard recommended program was followed for insect and disease control.

Weather Data (Fremont, Ohio)

	Temperature	
	1984	30 Yr. Av.
April	47.2	48.0
May	55.1	58.7
June	72.2	68.2
July	70.9	72.3
August	70.5	70.3
September	60.5	63.9

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	Rainfall (inches)	
	1984	30 Yr. Av.
April	0.26	3.19
May	4.81	3.46
June	1.96	4.02
July	2.82	4.01
August	3.20	3.51
September	2.52	3.00

Harvest was with an FMC tomato harvester and was carried out when the entries were estimated to be at a stage of fruit ripeness in which yields of marketable fruit were approaching optimum recovery with a minimum of green and cull fruit (Tables 1 and 3). Percentages reported of fruit recovery are on a weight basis.

Twenty field-run, hand picked tomatoes were randomly selected and used for raw product quality evaluation in accordance with methods previously described by Gould *et al.* (6, 7) for pH, acidity, soluble solids, and color (Tables 2 and 4). All laboratory samples were harvested by hand on Sept. 5 and evaluated the following day.

RESULTS AND DISCUSSION

Excessive precipitation and surplus topsoil moisture characterized the planting season. Moisture was adequate through the remainder of the season. July temperatures were below normal and delayed the crop. The remainder of the season temperature was normal and the crop was not subjected to high temperature stress.

The data for the new experimental lines are organized according to maturity groups and within maturity by once-over machine-harvest fruit yield. Because of the complexity of factors which determine a potentially successful variety, other factors which must be considered and can be limiting are included; *e.g.*, fruit concentration, fruit cull percentage, fruit size, stemming character, jointlessness, and the quality characteristics of pH, acidity, soluble solids, and color. It must be stressed that to adequately evaluate these lines, at least 1 or 2 more years of testing will be necessary.

The Ohio 832 is a main season Verticillium-Fusarium resistant line, high color crimson type, which has demonstrated excellent potential. It is firm, holds well on the vine, and is suitable for use in whole pack and processed products. Commercial acreage is already extensive and will increase in 1985. Commercial seed lots are available.

The Ohio 8129 continues to exhibit excellent potential in commercial plantings. It is an early-main season, machine harvest, jointless pedicel type suitable for whole pack or processed product. Commercial seed lots are available.

The Ohio 7983 has been extensively evaluated and is very promising as an early, high quality, machine harvest, jointless pedicel whole pack type. It has exhibited greatest potential in Canada.

The Ohio 8243 and 8245 are both productive, early-main season, jointless pedicel, machine harvest lines with Fusarium and Verticillium resistance. They are suitable for coreless whole pack, as well as processed products. There will be extensive trial commercial acreage of these lines in 1985 and commercial seed is available.

The Ohio 8431 is a Fusarium-Verticillium resistant line possessing some of the heat tolerance fruit setting ability of Ohio 7663, but with improved productivity and disease resistance (1). It is being advanced to more extensive trials.

This season the newly advanced lines Ohio 8239, 8383, 8439, and 8444 especially excelled for improved earliness, productivity, disease resistance, and quality. These will be more fully evaluated in 1985 OARDC as well as commercial grower-processor trials. In general this season, because of a minimum of stress, productivity was limited more by inherent vine size than by fruit setting ability. Thus, factors other than yield were of prime consideration.

Newly advanced lines with Bacterial Speck resistance showed good potential, such as Ohio 8436, 8438, 8440, 8441, 8442, 8445, and 8446. Bacterial canker was also observed and basis strain-resistance studies were continued with this disease (8).

In the trials, overall pH values tended to be undesirably high; however, acidity was in a normal range. Soluble solids levels in general were in a normal range; however, many of the newer lines would be more desirable if solids were higher and breeding work toward improving this quality factor is already in progress. All of the remaining enumerated experimental lines have improved attributes which give them potential for advancement to varietal status, but the all-important characteristic of seasonal adaptability and dependable productivity remains to be determined through further trial.

SEED SOURCES

1. Campbell Soup Co., Campbell Institute for Agricultural Research, Napoleon, Ohio.
2. Ferry-Morse Seed Co., San Juan Bautista, Calif.
3. H. J. Heinz Co., Agricultural Research, Bowling Green, Ohio.
4. Purdue University, Dept. of Horticulture, West Lafayette, Ind.
5. The Ohio State University, OARDC, Dept. of Horticulture, Wooster, Ohio.

TABLE 1.—Trial I: Field Evaluation of Processing Tomato Varieties and Test Lines for Mechanical Harvest when Yields of Marketable Fruit Were Approaching Optimum Recovery, OARDC Vegetable Crops Branch, Fremont, 1984.

Variety or Test Line	Ripe Usable Tons/A	Ripe Usable Percent of Potential	Percent of Potential Cull	Fruit Size (oz)	Stems Percent	Stems (j2 = jointless) (+ = jointed)
Harvest Date 8/27/84						
Ohio 8441	16.5	76	6	2.5	1	j2
Ohio 8442	14.4	71	8	2.5	0	j2
Harvest Date 9/4/84						
Ohio 8383	25.4	85	9	3.4	1	j2
Ohio 7814	24.9	82	6	2.5	1	j2
Ohio 8243	24.7	82	3	2.5	2	j2
Ohio 8440	23.8	82	6	2.6	1	j2
Ohio 8449	23.4	86	4	3.0	28	+
Ohio 8431	23.1	83	7	3.0	1	j2
Ohio 8445	22.7	79	5	2.4	1	j2
Ohio 8363	22.1	82	4	2.6	1	j2
Heinz 2653	21.9	78	10	2.8	2	j2
Heinz 722	21.9	80	3	2.4	3	j2
Ohio 8129	21.0	83	7	2.6	0	j2
Ohio 8430	20.8	79	7	2.6	0	j2
Ohio 8283	20.6	83	10	3.4	3	j2
Ohio 832	20.6	74	10	3.3	66	+
FM 6203	20.4	84	7	3.3	23	+
Ohio 8136	20.3	83	9	3.1	11	j2
C 4135	20.0	76	5	2.7	0	j2
Ohio 8436	17.6	69	7	3.0	0	j2
Ohio 8446	16.8	78	8	2.6	0	j2
Ohio 8444	13.7	72	11	3.1	4	j2
Harvest Date 9/11/84						
Ohio 8355	25.8	81	8	3.2	0	j2
Ohio 7870	25.0	83	6	3.2	71	+
Ohio 8239	24.9	85	6	3.1	0	j2
Ohio 8295	24.7	72	9	3.6	1	j2
Ohio 8297	23.0	78	8	3.1	1	j2
Ohio 8439	21.9	81	7	3.0	1	j2
Ohio 8358	21.7	81	8	2.8	0	j2
Ohio 831	21.3	78	8	3.2	14	+
Ohio 7983	20.5	79	9	2.6	1	j2
Ohio 8374	20.0	72	9	2.9	0	j2
Ohio 8438	19.1	69	17	3.2	81	+
LSD 5%	4.5			0.2		

TABLE 2.—Trial I: Laboratory Evaluation of Processing Tomato Varieties and Test Lines, OARDC Vegetable Crops Branch, Fremont, 1984.

Variety or Test Line	pH	Percent Citric Acid	Percent Soluble Solids	Color: Hunter Color Difference Meter L	Color: Hunter Color Difference Meter a/b	Color: Agtron E5
Ohio 8441	4.49	0.31	5.7	30.42	2.48	33
Ohio 8442	4.41	0.37	5.3	25.98	2.49	31
Ohio 8383	4.49	0.29	5.3	26.73	2.76	29
Ohio 7814	4.40	0.36	5.6	28.92	2.45	33
Ohio 8243	4.35	0.39	5.0	28.11	2.64	30
Ohio 8440	4.50	0.29	4.8	25.82	2.70	30
Ohio 8449	4.39	0.37	5.2	26.99	2.52	30
Ohio 8431	4.42	0.29	5.1	27.05	2.33	31
Ohio 8445	4.42	0.29	5.1	27.05	2.33	31
Ohio 8363	4.39	0.41	5.7	27.62	2.67	30
Heinz 2653	4.49	0.38	6.3	24.07	2.51	28
Heinz 722	4.35	0.46	6.2	28.24	2.66	31
Ohio 8129	4.50	0.29	5.5	28.31	2.59	32
Ohio 8430	4.49	0.31	5.2	27.61	2.48	30
Ohio 8283	4.41	0.40	6.2	26.35	2.86	27
Ohio 832	4.51	0.33	6.0	25.14	2.85	27
FM 6203	4.35	0.30	6.0	27.09	2.43	29
Ohio 8136	4.38	0.32	5.2	26.43	2.54	29
C 4135	4.42	0.35	6.2	27.48	2.57	32
Ohio 8436	4.31	0.30	5.0	28.57	2.52	31
Ohio 8446	4.24	0.36	5.1	27.07	2.60	30
Ohio 8444	4.19	0.47	5.7	29.49	2.23	34
Ohio 8355	4.35	0.35	6.2	28.49	2.46	32
Ohio 7870	4.45	0.29	5.2	27.41	2.65	32
Ohio 8239	4.29	0.32	5.6	29.49	2.55	32
Ohio 8295	4.51	0.24	4.6	25.31	2.58	32
Ohio 8297	4.31	0.34	6.0	28.86	2.55	33
Ohio 8439	4.48	0.29	5.4	25.10	2.63	29
Ohio 8358	4.28	0.37	5.5	27.59	2.54	30
Ohio 831	4.39	0.28	5.8	25.08	2.69	27
Ohio 7983	4.40	0.33	5.2	26.67	2.49	30
Ohio 8374	——	——	5.1	27.35	2.48	31
Ohio 8438	4.41	0.29	5.2	28.26	2.27	32

TABLE 3.—Trial II: Field Evaluation of Processing Tomato Varieties and Test Lines for Mechanical Harvest when Yields of Marketable Fruit Were Approaching Optimum Recovery, OARDC Vegetable Crops Branch, Fremont, 1984.

Variety or Test Line	Ripe Usable Tons/A	Ripe Usable Percent of Potential	Percent of Potential Cull	Fruit Size (oz)	Stems Percent	Stems (j2 = jointless) (+ = jointed)
Harvest Date 9/4/84						
Ohio 8457	28.0	82	4	2.9	3	j2
Ohio 8479	25.8	81	8	3.3	1	j2
Ohio 8471	24.4	78	8	3.8	1	j2
Ohio 8489	24.2	77	9	5.3	91	+
Ohio 8485	23.4	79	10	2.7	0	j2
Ohio 8492	23.2	83	6	2.9	4	+
Ohio 8458	22.7	.75	4	2.7	0	j2
Ohio 8465	22.2	87	3	2.9	58	+
Harvest Date 9/7/84						
Ohio 8468	26.4	78	6	2.9	0	j2
Ohio 8478	25.4	81	4	3.1	2	j2
Ohio 8480	25.3	77	5	3.2	0	j2
Ohio 7870	25.2	83	3	3.3	60	+
Ohio 8493	23.8	78	8	2.9	0	j2
Ohio 8494	23.0	82	3	2.4	0	j2
Ohio 8083	22.5	71	5	3.1	0	j2
Ohio 8490	22.4	74	7	3.3	0	j2
Ohio 8482	21.7	80	6	3.1	4	+
Ohio 8472	18.3	76	16	2.9	1	j2
Harvest Date 9/11/84						
Ohio 8470	28.3	79	7	3.2	0	j2
Ohio 8461	26.9	85	7	3.7	0	j2
Ohio 8460	26.0	76	10	3.6	0	j2
Ohio 8477	24.8	78	10	3.5	0	j2
Ohio 8475	24.3	75	9	3.2	1	j2
Ohio 8464	24.2	81	8	3.0	0	j2
PU 812	24.0	83	4	2.5	11	+
Ohio 8456	23.8	79	11	2.5	0	j2
Ohio 8488	23.7	80	7	3.4	22	+
Ohio 8487	22.6	75	11	3.6	1	j2
Ohio 8483	20.9	79	11	3.0	0	j2
Ohio 8481	18.4	72	10	2.7	0	j2
LSD 5%	NS			0.3		

TABLE 4.—Trial II: Laboratory Evaluation of Processing Tomato Varieties and Test Lines, OARDC Vegetable Crops Branch, Fremont, 1984.

Variety or Test Line	pH	Percent Citric Acid	Percent Soluble Solids	Color: Hunter Color Difference Meter L	Color: Hunter Color Difference Meter a/b	Color: Agtron E5
Ohio 8457	4.45	0.32	4.8	27.59	2.61	31
Ohio 8479	4.48	0.29	5.2	27.03	2.68	30
Ohio 8471	4.51	0.28	4.8	26.49	2.81	31
Ohio 8489	4.60	0.25	5.0	26.02	2.65	30
Ohio 8492	4.49	0.29	4.8	27.01	2.61	31
Ohio 8458	4.50	0.29	5.1	27.47	2.60	30
Ohio 8465	4.46	0.24	4.9	27.53	2.59	33
Ohio 8468	4.38	0.31	5.8	28.28	2.36	32
Ohio 8478	4.49	0.33	4.6	25.76	2.66	29
Ohio 8480	4.41	0.33	5.3	28.35	2.48	32
Ohio 7870	4.46	0.30	5.2	28.65	2.68	32
Ohio 8494	4.48	0.29	4.6	28.95	2.47	35
Ohio 8038	4.40	0.31	5.1	27.92	2.51	32
Ohio 8490	4.45	0.30	4.5	26.95	2.67	32
Ohio 8482	4.45	0.31	5.5	27.40	2.80	30
Ohio 8472	4.51	0.32	5.7	26.03	2.64	31
Ohio 8470	4.41	0.27	4.6	29.76	2.17	33
Ohio 8461	4.38	0.32	5.3	25.08	2.87	28
Ohio 8460	4.41	0.32	5.7	25.12	2.83	28
Ohio 8477	4.41	0.30	5.0	27.22	2.78	28
Ohio 8475	4.48	0.25	4.8	28.93	2.29	35
Ohio 8464	4.51	0.24	4.8	27.73	2.58	32
PU 812	4.51	0.29	5.3	27.10	2.68	30
Ohio 8456	4.51	0.27	5.7	25.91	2.62	31
Ohio 8488	4.55	0.23	4.6	26.67	2.49	29
Ohio 8487	4.42	0.29	4.4	27.39	2.39	34
Ohio 8483	4.55	0.29	5.3	27.49	2.72	30
Ohio 8481	4.51	0.28	5.1	26.99	2.58	32

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The Influence of Spacing and Nitrogen Rate on Yield and Hollow Stem in Broccoli[1]

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ABSTRACT

Various cultivars of broccoli (*Brassica oleracea* var. *italica*) were grown in spring and fall crops in Ohio to evaluate the effects of plant spacing and nitrogen rates on yield, percent hollow stem, and head size (diameter and weight). Within-row spacings were 20, 30, and 40 cm. Nitrogen rates were 0, 112, 168, and 224 kg N/ha. Closer spacing and higher plant densities increased yields while decreasing head size (diameter and weight) and the incidence of hollow stem. Increasing nitrogen rate increased yield, head size (diameter and weight), and the incidence of hollow stem.

INTRODUCTION

Plant spacing has been shown to have an influence on the yield and quality of broccoli. Zink and Akana (11) studied the effect of various within-row spacings and found that head and stem diameter increased as spacing increased. However, due to larger plant populations, the actual number of heads of suitable size were greater at close spacings. Several researchers (1, 6) have shown that closer within-row spacing and/or higher densities resulted in higher yields.

Nitrogen rates have been shown to influence total yield, average size, earliness, and tissue composition of many horticultural crops. With broccoli, selection of a nitrogen rate which will promote even growth is preferred, since rapid growth can promote hollow stem and reduce yields, respectively. Nieuwhof (7) suggested 60 to 79 kg N/ha at planting and one to three side dressings of 40 kg N/ha. Roberts *et al.* (9) recommended 168 kg N/ha broadcast and plowed down with a side-dressing of 56 to 112 kg N/ha as the heads are beginning to form.

There are conflicting reports concerning the interaction between plant spacing and nitrogen rate in horticultural crops. No interaction was found in peppers (*Capsicum annum* L.) (2), cucumbers (*Cucumis sativus* L.) (8), or beets (*Beta vulgaris* L.) (5). With watermelon (*Citrulla lanatus* Thunb.), there was a significant interaction between row spacing, mulch, and fertilizer on fruit yield per plant (3).

Cutcliffe (4) found no interaction between spacing and nitrogen rate on marketable yields in single-harvested broccoli. Zink (10) found a significant interaction when spacing and nitrogen rates were varied.

This study was undertaken to examine the influence of spacing and nitrogen rate on yield, percent hollow stem, and head size (diameter and weight) in broccoli.

[1]The authors would like to thank Gerry Myers, Ms. Marianne Roberts, Jerry Baron, and Ms. Monica Wertz for their assistance during this study and the preparation of this manuscript.

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MATERIALS AND METHODS

Three broccoli cultivars were selected for the spring study: 'Bravo', 'Green Comet', and 'Green Duke'. 'Bravo', 'Green Hornet', 'Green Valiant', and 'Premium Crop' were used for the fall planting. Seedlings were raised in the greenhouse for both studies and transplanted to the field on April 13 and July 20, respectively.

Soil was formed into raised beds (5-8 cm high) 5.4 meters long and on 1.5 meter centers. Two rows (40 cm apart) of plants were placed on each bed. Plants were staggered in the row so the plants were not directly opposite each other. Within-row spacings of 20, 30, and 40 cm were used for both the spring and fall plantings and resulted in average densities of 6.7, 4.4, and 3.3 plants/m^2. Transplanting was done by hand.

Ammonium nitrate (33% nitrogen) was used as the nitrogen source. Nitrogen rates for the spring planting were 0, 112, 168, and 224 kg N/ha. Rates for the fall planting were 112, 168, and 224 kg N/ha. Half of each nitrogen rate was applied to the field pre-plant and incorporated 5-8 cm deep. The remaining half of the nitrogen for the spring crop was sidedressed as each cultivar developed heads 1 to 2.5 cm in diameter.

Nitrogen sidedressing for the fall crop was applied on August 17. This was 6 days prior to 'Bravo' developing heads 1 to 2.5 cm in diameter, 10 days prior to 'Green Hornet' and 'Premium Crop', and 20 days prior to 'Green Valiant' developing similar size heads.

Center heads were sequentially harvested when the buds started to swell but before they began to open. All treatments for a given cultivar were harvested on the same date. The spring crop was harvested six times. There were eight cuttings on the fall crop.

Each treatment was evaluated for the following factors at each harvest: number of heads harvested, head weight, average head diameter, and number of heads with hollow stem.

This study was a factorial experiment (cultivar x spacing x nitrogen rate) and was replicated four times. Data were statistically analyzed using Fisher's LSD at the 5% level significance.

RESULTS AND DISCUSSION

As plant spacing within rows decreased, there was a tendency for both early (harvests 1, 2 and 3 combined) and total yields to increase (Tables 1 and 2). However, the differences were not always significant. Early yields for the spring crop showed no significant differences, whereas early yields for the fall crop were significantly greater at the 20 cm spacing than at greater spacings. Total yields for both the spring and fall crops were significantly increased as plant spacing decreased.

Increased spacing (analyzed over all cultivars and nitrogen rates) significantly increased the incidence of hollow stem, average head diameter, and average head weight in both the spring and fall crops (Tables 1 and 2). As the size (diameter and weight) of the head increased, the percentage of heads with hollow stem increased. The fall broccoli crop produced larger heads (diameter and weight) than the spring crop due to improved environmental conditions.

Increased nitrogen rates tended to increase early and total yield, percent hollow stem, average head diameter, and average head weight for both the spring and fall crops (Tables 1 and 2). However, not all differences were significant.

When all cultivars and spacings are combined, plants treated with 168 or 224 kg N/ha had significantly higher early yields than either 0 or 112 kg N/ha (spring) or 112 kg N/ha (fall). Plants treated with 112 kg N/ha (spring) produced significantly higher early yields than those plants receiving no (0 kg N/ha) nitrogen.

In the spring study, total yield was significantly increased with each increase in nitrogen rate. Total yields were not significantly different for the 168 and 224 kg N/ha treatments in the fall study. Plants receiving 112 kg N/ha (fall) produced total yields which were significantly lower than those treated with 168 or 224 kg N/ha.

In the spring study, the percentage of heads with

TABLE 1.—Head Weight, Percent Hollow Stem, Average Head Diameter, and Average Head Weight for Spring-Planted Broccoli.

Within Row Spacing (cm)*	Head Weight (kg/5.4 m row) Early†	Total‡	Percent Hollow Stem	Average Head Diameter (cm)	Average Head Weight (g)
20	1.8	3.1	8.2	7.2	60
30	1.8	2.8	15.6	7.9	80
40	1.6	2.3	24.2	8.5	100
LSD 5%	NSD	0.2	5.3	0.4	9
Nitrogen Rate (kg N/ha)**					
0	0.5	1.2	3.0	5.7	40
112	1.7	2.7	15.6	7.9	80
168	2.3	3.3	20.2	8.6	100
224	2.4	3.7	25.1	9.2	110
LSD 5%	0.3	0.3	6.1	0.4	11

*All cultivars and spacings combined.
†Early yield consists of harvests 1-3 combined.
‡Total yields consist of all harvests (1-6) combined.
**All cultivars and spacings combined.

TABLE 2.—Head Weight, Percent Hollow Stem, Average Head Diameter, and Average Head Weight for Fall-Harvested Broccoli.

Within Row Spacing (cm)*	Head Weight (kg/5.4 m row) Early†	Total‡	Percent Hollow Stem	Average Head Diameter (cm)	Average Head Weight (g)
20	5.7	9.4	30.2	10.2	220
30	5.0	8.2	41.5	11.3	260
40	4.6	7.0	56.4	12.2	310
LSD 5%	0.6	0.7	8.0	0.5	19
Nitrogen Rate (kg N/ha)**					
112	4.5	7.5	35.9	10.7	240
168	5.4	8.3	46.7	11.5	270
224	5.4	8.7	45.5	11.4	280
LSD 5%	0.6	0.7	8.0	0.5	19

*All cultivars and spacings combined.
†Early yield consists of harvests 1-3 combined.
‡Total yields consist of all harvests (1-8) combined.
**All cultivars and spacings combined.

hollow stem obtained with the 168 kg N/ha treatment was not significantly different from the 112 or 224 kg N/ha treatments. All other treatment comparisons were significantly different. Plants treated with 168 or 224 kg N/ha in the fall were statistically similar and significantly greater than the 112 kg N/ha treatment for percentage hollow stem.

In general, as the rate of nitrogen increased so did the average head diameter and average head weight. Exceptions to this are the 168 and 224 kg N/ha rates in the spring and fall for average head weight and in the fall for average head diameter.

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Tolerance of Four Vegetable Crops to Selected Herbicides

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ABSTRACT

The sensitivity of direct seeded cucumber, tomato, cabbage, and lettuce to pre-emergent treatments of trifluralin, metribuzin, and metolachlor was evaluated under greenhouse conditions. Trifluralin caused significant reduction in shoot fresh weight, plant height, and leaf area in all tested species. Vegetable crops were sensitive to metribuzin at the lowest rate evaluated (0.028 kg/ha). Metolachlor had variable effects on the tested species at the rates evaluated. Lettuce was adversely affected by all chemicals tested.

INTRODUCTION

Herbicides are continually tested in horticultural crops to identify those which will give better control of weeds with improved crop selectivity. The problem of evaluating new as well as existing herbicides is complex. The herbicide must be sufficiently selective to give near perfect control of weeds without damaging the crop plant, yet not be persistent enough to damage succeeding crops (4, 5).

Trifluralin, metribuzin, and metolachlor are important herbicides in the production of several horticultural and agronomic crops. Soil persistence of these herbicides has been studied by several researchers at different locations in the United States to determine carryover to subsequent cropping systems (1, 6, 7). Trifluralin is a widely used herbicide for the control of annual grass and some broadleaf weeds in several horticultural crops. Metribuzin is registered for weed control in potatoes, tomatoes, and asparagus, and has potential for use in several other vegetable crops. Metolachlor is currently registered for use in potatoes, corn (including sweet corn), and soybeans. These herbicides all have a soil residual which lasts several weeks. Repeated annual applications may promote a soil buildup and long-lasting residue. These potential residues are of concern to vegetable growers as many vegetable species are sensitive to these herbicides.

Researchers, extension agents, and growers need more information about the herbicide sensitivity of specific vegetable crops. Herbicide residues, if present, may result in significant crop losses.

A simple way of determining the presence of herbicide residues in soils is with a biological assay (3). Combining the results of a bioassay with known crop sensitivity data to that particular herbicide, a researcher/grower can make a more educated decision of which crop to plant in a particular field.

The major objective of this study was to determine the sensitivity of four vegetable crops (cucumber, tomato, cabbage, and lettuce) to three herbicides (trifluralin, metolachlor, and metribuzin).

METHODS AND MATERIALS

A silty loam soil (4.4% organic matter, pH 7.5) was placed in plastic flats (7.6 x 35.5 x 55.9 cm). Twenty seeds each of tomato, cabbage, and lettuce and 15 cucumber seeds were sown 2.5 cm deep in each flat.

After the vegetable seeds were sown, the herbicides were applied to the soil surface. Herbicides were applied using a conveyor-type greenhouse sprayer delivering an application volume of 1,290 l/ha at a sprayer pressure of 2.11 kg/m^2. Flats were then placed on a greenhouse bench in a randomized complete block design. Each treatment was replicated four times. Herbicides were initially incorporated into the soil by irrigation. Flats were then watered daily. Care was taken not to flood the flats or overwater and cause leaching of the herbicide from the bottom of the flat. Greenhouse temperatures were maintained at 20° C.

The experiment ran for 30 days. At the end of this period, plants were harvested. Treatment effects were determined by measuring plant stand (percent germination), plant height, fresh and oven dried weights, and total leaf area (using a portable leaf area meter). Percent germination was not reported for metribuzin treated plants. Plant survival indicated plants which were living at the end of the experimental period. Data were analyzed by analysis of variance and means were separated using Duncan's new multiple range test at the 5% level of significance.

RESULTS AND DISCUSSION

Results for plant dry weight, height, and leaf ara were similar to plant fresh weight (2). Therefore, they are not presented in this article.

Trufluralin

Cucumber shoot fresh weight was significantly reduced, even at the lowest rate (0.028 kg/ha) of trifluralin tested (Table 1). Germination of cucumbers was not as severely affected as fresh weight. Trifluralin rates below 1.12 kg/ha did not significantly reduce germination. This response was expected and understandable since trifluralin is not a germination inhibiting herbicide. Rather, it interferes with root growth and subsequent vegetative development.

Tomato, cabbage, and lettuce responded similarly to cucumber (Table 1). Fresh weight was significantly reduced with the lowest rate of trifluralin tested. Germination was also significantly reduced at the lowest rate of trifluralin evaluated for these three crops.

Cabbage germination and growth response to trifluralin in this experiment is notable. Trifluralin is a

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TABLE 1.—Effects of Trifluralin on Cucumber, Tomato, Cabbage, and Lettuce Seed Germination and Shoot Fresh Weight.*

Trifluralin (kg/ha)	Cucumber Germination (%)	Cucumber Shoot Fresh Weight (g)	Tomato Germination (%)	Tomato Shoot Fresh Weight (g)	Cabbage Germination (%)	Cabbage Shoot Fresh Weight (g)	Lettuce Germination (%)	Lettuce Shoot Fresh Weight (g)
0.00	97.0a	67.0a	94.5a	24.0a	77.5a	48.0a	80.0a	22.8a
0.028	80.0abc	32.3b	68.8b	16.3b	55.0c	16.5bcd	30.0b	18.8b
0.056	80.0abc	35.8b	68.8b	16.0b	40.0d	14.3cd	27.5bc	17.8bc
0.112	81.5abc	25.8b	70.0b	16.3b	41.3cd	25.5bc	21.3bcd	17.5bc
0.28	82.3abc	37.0b	75.0b	15.5b	46.3cd	16.0bcd	18.8cd	17.0bc
0.56	79.3abc	30.5b	75.0b	17.3b	38.8d	28.8b	18.8cd	8.8e
0.84	87.0ab	23.5b	73.8b	14.0b	43.8d	19.5bcd	20.1bcd	10.5de
1.12	72.0bc	22.5b	71.3b	6.3c	65.0b	13.0cd	11.3d	13.8cd
2.24	64.3c	20.3b	66.3b	5.0c	12.5e	9.5d	0.0e	0.0f

*Means in the same column followed by the same letter are not significantly different at the 0.5 level according to Duncan's new multiple range test.

TABLE 2.—Effects of Metribuzin on Cucumber, Tomato, Cabbage, and Lettuce Plant Survival and Shoot Fresh Weight.*

Metribuzin (kg/ha)	Cucumber Plant Survival (%)	Cucumber Shoot Fresh Weight (g)	Tomato Plant Survival (%)	Tomato Shoot Fresh Weight (g)	Cabbage Plant Survival (%)	Cabbage Shoot Fresh Weight (g)	Lettuce Plant Survival (%)	Lettuce Shoot Fresh Weight (g)
0.00	97.5a	75.0a	95.0a	22.3a	92.0a	17.8a	83.8a	15.8a
0.028	80.0b	58.0b	80.0ab	17.3b	52.5b	13.8ab	43.8b	10.3b
0.056	74.3b	48.0b	77.5b	18.0ab	16.3c	10.3b	0.0c	0.0c
0.112	73.3b	56.3b	78.8ab	16.5b	0.0d	0.0c	0.0c	0.0c
0.28	66.3b	47.8b	75.0b	16.0b	0.0d	0.0c	0.0c	0.0c
0.56	65.5b	34.0c	10.0c	2.5c	0.0d	0.0c	0.0c	0.0c
0.84	0.0c	0.0d	0.0c	0.0c	0.0d	0.0c	0.0c	0.0c
2.24	0.0c	0.0d	0.0c	0.0c	0.0d	0.0c	0.0c	0.0c

*Means in the same column followed by the same letter are not significantly different at the 0.5 level according to Duncan's new multiple range test.

TABLE 3.—Effects of Metolachlor on Cucumber, Tomato, Cabbage, and Lettuce Seed Germination and Shoot Fresh Weight.*

Metolachlor (kg/ha)	Cucumber Germination (%)	Cucumber Shoot Fresh Weight (g)	Tomato Germination (%)	Tomato Shoot Fresh Weight (g)	Cabbage Germination (%)	Cabbage Shoot Fresh Weight (g)	Lettuce Germination (%)	Lettuce Shoot Fresh Weight (g)
0.00	96.5a	84.5a	89.3a	34.0a	88.3a	26.0a	71.3a	15.0a
0.028	88.3ab	52.0bc	85.0ab	15.8b	52.5b	13.0bc	27.5b	10.0b
0.056	79.3abc	45.0bcd	75.0abc	13.8bc	54.8b	16.0b	20.0bc	9.0c
0.112	74.5bc	50.3bc	73.8abcd	16.3b	35.0bcd	13.0bc	15.0c	7.3d
0.28	83.3ab	59.8b	77.5abc	15.5b	23.8cd	10.5bc	18.8c	7.0d
0.56	78.3abc	57.0b	72.5abcd	13.5bc	42.5bc	14.5b	0.0d	0.0e
0.84	90.0ab	47.8bcd	70.0bcd	16.3b	32.5bcd	12.3bc	0.0d	0.0e
1.12	81.8ab	39.5bcd	76.3abc	14.3bc	41.3bc	16.5b	0.0d	0.0e
1.68	86.8ab	45.5bcd	57.5de	8.5bc	30.0bcd	16.5b	0.0d	0.0e
2.24	88.3ab	27.5d	66.3cd	12.5bc	38.8bc	15.3b	0.0d	0.0e
4.48	60.8c	31.5cd	50.0e	6.5c	12.5d	4.0c	0.0d	0.0e

*Means in the same column followed by the same letter are not significantly different at the 0.5 level according to Duncan's new multiple range test.

registered herbicide recommended for use on field-seeded cabbage at rates of 0.56 to 1.12 kg/ha. Plant stunting has been observed in direct-seeded cabbage fields which have been treated with trifluralin. These observations are substantiated by the findings of this study.

Lettuce was more severely affected by trifluralin than the other three crops tested. Germination was only 38% of the untreated control at the lowest rate tested (0.028 kg/ha). Shoot fresh weight was significantly reduced as the rate of trifluralin increased. This suggests that lettuce would be a good indicator species for testing trifluralin residues in soil.

Metribuzin

Cucumber and tomato exhibited slightly more tolerance to metribuzin than cabbage and lettuce (Table 2). All crops tested were sensitive to metribuzin at the lowest rate evaluated (0.028 kg/ha). Tomatoes and cucumbers were killed at rates of 0.84 kg/ha and above. Cabbage was more sensitive than tomato and cucumber, with death occurring at 0.112 kg/ha. Lettuce was the most susceptible crop, with death occurring at rates of 0.056 kg/ha and above.

Visual injury symptoms began as a leaf chlorosis within 2 days of seedling emergence. This chlorosis progressed to marginal leaf necrosis, complete leaf necrosis, and in some cases plant death. For this reason, percent germination was not measured. Plant survival was believed to be a more meaningful parameter since it would take into account those plants which died shortly after germination. Plant stunting (height and leaf size) was also observed.

In most cases, growth variables were significantly reduced by the lowest rate of metribuzin applied. Percent plant survival and shoot fresh weight generally declined with increasing rates of metribuzin.

Metribuzin proved to be quite phytotoxic to all plant species tested in this experiment. Data suggest that yield reductions could occur if these vegetables were planted in soils containing metribuzin residues as low as 0.028 kg/ha.

Lettuce, being affected most severely, would be the most appropriate species to test for metribuzin soil residues.

Metolachlor

Pre-emergence application of metolachlor appeared to have variable effects on the tested species (Table 3). Cucumber and tomato exhibited more tolerance to metolachlor than cabbage and lettuce. Germination in cucumber and tomato decreased as the rate of metolachlor increased. Cabbage germination was significantly decreased with increasing rates. Lettuce germination was completely inhibited at rates of 0.56 kg/ha and higher.

Seedlings of all crops showed different degrees of chlorosis and stunting of growth, which is in agreement with the reported mode of action of metolachlor. Shoot fresh weight was significantly decreased in all tested species.

SUMMARY AND CONCLUSIONS

Trifluralin caused a significant reduction in shoot fresh weight of cucumber seedlings at rates of 0.112 kg/ha. Germination was not severely affected by rates below 1.12 kg/ha. Tomato, cabbage, and lettuce responded similarly. Lettuce was the most susceptible crop to trifluralin.

All species tested showed sensitivity to metribuzin at the lowest rate evaluated (0.028 kg/ha). Cucumber and tomato were completely killed at the rate of 0.84 kg/ha. Cabbage was more sensitive to metribuzin than cucumber and tomato, with death of seedlings at 0.112 kg/ha. Lettuce cannot tolerate metribuzin even at its lowest rate tested (0.028 kg/ha). This might suggest lettuce as a good indicator species for metribuzin soil residues.

Metolachlor had variable effects on the species tested at the rates evaluated. Cucumber and tomato exhibited higher tolerance to metolachlor than cabbage and lettuce. Lettuce germination was significantly reduced at the lowest rate evaluated (0.028 kg/ha), with complete inhibition of germination at 0.056 kg/ha. All species suffered severe chlorosis and stunting of growth.

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The Effects of Shoot Tip Removal and Various Levels of Defoliation on the Growth and Yield of Cucumbers (*Cucumis sativus*, L.)

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ABSTRACT

Removal of shoot tips and five levels of defoliation were performed on 'Marketmore 76', a monoecious, slicing cucumber cultivar. Treatments were performed at anthesis of the first pistillate flowers, at first harvest, and at third harvest. The number of secondary laterals increased with increasing levels of defoliation. The increases were not always statistically significant, however. The rate and amount of regrowth appeared to be greater when treatments were performed at anthesis. Shoot tip removal alone and 25% defoliation at anthesis did not significantly reduce yields. When treatments were performed at first and third harvest, plants could sustain up to 50% defoliation without significant yield reductions. Treatments did not alter sex expression in this study.

INTRODUCTION

Cucumber plants, having large leaves and sprawling habit, are subject to considerable injury from foliar disease and hail, and injury to shoot tips and leaves from trampling by laborers during hand-harvesting.

Loss of photosynthetic leaf area has been shown to limit the amount of carbohydrates available for growth and fruit development in some crops. Removal of shoot tips has been found to eliminate a major carbohydrate sink as well as a source of auxin which inhibits lateral branch development (1, 2, 3, 6, 7, 8, 10).

The effects of partial defoliation and removal of the terminal growing point have been extensively studied in many crops. Little research, however, has been conducted with cucumbers. The potential for vegetative regrowth of other crops has been shown to be dependent on the stage of plant development at which defoliation occurs (1, 3, 8, 11, 13). Results have also shown that fruit set and subsequent development can be influenced by the stage of growth at which injury occurs, as well as the degree of defoliation (1, 2, 5, 12, 13).

The primary objectives of this study were to: 1) investigate the effects of shoot tip removal and several levels of defoliation on vegetative growth of cucumber plants, 2) determine if there are alterations in sex expression as a result of shoot tip removal and defoliation, and 3) determine the effects of shoot removal and several levels of defoliation on cucumber yields.

MATERIALS AND METHODS

Seeds of 'Marketmore 76', an open-pollinated, fresh market, monoecious cultivar, were direct-seeded on raised beds at The Ohio State University Horticulture Research Farm, Columbus. Beds were cultivated and covered with black plastic mulch before planting. Seeds were planted approximately 30.5 cm apart in rows on 1.6 m centers. After germination, seedlings were thinned to two plants per hill. Treatment plots were 7.6 m long. Yield data were taken from 6.1 m of row with 19 hills per row. Growth response and sex expression data were taken from the remaining 1.5 m of row containing five hills.

Plant tissue removal treatments were performed at three stages of growth: 1) anthesis of the first pistillate flowers, 2) first harvest, and 3) third harvest. Defoliation treatments consisted of removal of 0, 25, 50, 75, and 100% of the leaves. All plants had the shoot tips removed from the main stem and lateral branches. A control with no shoot tip or leaf removal was included.

One of every four leaves was randomly clipped near the stem for the 25% defoliation treatment. Removal of 50% of the leaves was accomplished by clipping two of every four leaves. Three of every four leaves were clipped for the 75% defoliation, and all leaves were removed for the 100% defoliation treatment. Shoot tips were removed by taking a 7.6 cm pinch from each terminal over the entire plant canopy.

Plot design was a randomized complete block with three replications. Data were analyzed using Duncan's new multiple range test at the 5% level of significance.

RESULTS AND DISCUSSION

Cucumber fruit was first harvested 7 days after application of the first treatment. Harvest continued thereafter at 5-day intervals for a total of eight harvests. Fruits were harvested as they reached marketable maturity.

Growth responses were evaluated 9, 18, and 30 days after each treatment application. One plant from each treatment/replicate was removed from the field by cutting the stem at ground level. Number of primary and secondary lateral branches, leaf area and number, and number of pistillate and staminate flowering nodes on the main stem, primary laterals, and secondary laterals were recorded.

It is not unexpected that removal of shoot tips from cucumber plants would increase the growth rate and number of lateral branches. Results also indicated that the number of secondary laterals increased with increasing levels of defoliation (Table 1). The increases were not always significant, however. Numbers of primary laterals for all treatments were statistically similar.

The rate and amount of vegetative regrowth were greater when treatments were applied at anthesis.

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TABLE 1.—Number of Secondary Lateral Branches and Leaf Area (cm^2) of Cucumber Plants 9, 18, and 30 Days After Treatment Application.*

Percent Defoliation at Anthesis	9 days		18 days		30 days	
	Secondary Laterals	Leaf Area	Secondary Laterals	Leaf Area	Secondary Laterals	Leaf Area
Control	4.7c	6916.0a	6.3a	7605.0a		7794.0a
0	14.3b	7625.1a	15.7a	6020.9a	22.7a	6452.5a
20	17.3ab	5619.3a	15.0a	5785.1a	25.3a	8505.4a
50	23.7ab	6967.5a	22.3a	7199.1a	17.7a	4219.9a
75	25.3a	3911.7ab	16.3a	4725.0a	21.0a	4983.6a
100	23.7ab	529.1b	20.3a	4332.2a	25.0a	6702.3a
First Harvest						
Control	8.0bc	7320.1a	10.3c	9477.0a	10.3c	17292.1a
0	3.3c	4268.1bc	22.0abc	7919.4a	22.0abc	7662.7a
25	17.3abc	6747.1a	29.7ab	7725.2a	29.7ab	8280.7a
50	19.0ab	5739.1ab	34.7a	8367.2a	34.7a	9043.5a
75	14.0bc	2613.9c	16.3bc	3298.1b	16.3bc	7598.5a
100	30.0a	381.7d	29.7ab	2362.1b	29.7ab	5602.2a
Third Harvest						
Control	16.7a	11058.3a	10.7a	9168.6a	10.7a	9705.4ab
0	16.7a	9657.1a	21.3a	7792.0ab	21.3a	8304.4abc
25	12.0a	7752.2a	32.0a	5856.5ab	31.0a	5795.8bc
50	19.0a	7380.0ab	14.7a	3743.2bc	14.7a	6014.1bc
75	17.3a	2281.2bc	30.3a	4230.6bc	30.3a	11688.6a
100	21.0a	416.2c	36.0a	605.4c	36.0a	3209.8c

*All treatments are with removal of shoot tips except the control. Means in the same column followed by the same letter are not significantly different at the 0.5 level according to Duncan's new multiple range test.

Plants recovered more slowly when defoliated at first and third harvest. This was attributed to competition with developing fruit for available assimilates.

The rate of regrowth was also greater for the more severe (75 and 100%) defoliation treatments. The reduced level of assimilates caused by removal of mature leaves was apparently not great enough to stop lateral branch development stimulated by removal of shoot tips and young leaves. The rate of photosynthesis of any remaining leaves may have increased, making more assimilates available.

The number of primary and secondary laterals of the 50, 75, and 100% defoliation treatments at anthesis reached an apparent maximum by 9 days after performing treatments. The control, tip removal alone, and 25% defoliation treatments initiated lateral shoots at a slower rate. When treatments were performed at first and third harvest, the number of laterals produced was greater but they were initiated at a slower rate compared with the treatments performed at anthesis.

Recovery of leaf area was greater for treatments performed at anthesis (Table 1). Where significant differences occurred, there were usually no differences between the control and up to 50% defoliation. The development of leaves on the newly initiated laterals contributed to the greater recovery in leaf area for 75 and 100% defoliation treatments. Leaf numbers showed very few significant differences (9).

It did not appear that shoot tip removal and defoliation treatments altered sex expression of cucumber plants (9). No significant differences in the ratio of

TABLE 2.—Number and Weight of Cucumbers, from All Harvests (8) Combined for Plants Defoliated at Three Different Times (Anthesis of First Pistillate Flowers, First Harvest, and Third Harvest).*

Percent Defoliation	Fruit Number	Fruit Weight (lb)
Control (1)†‡	359.7a	87.6abc
Control (2)	356.3a	85.5abcd
Control (3)	376.7a	90.0ab
0 (1)	363.0a	86.8abc
0 (2)	355.7a	82.6abcd
0 (3)	37.7a	108.4a
25 (1)	291.3abcd	67.7bcd
25 (2)	316.3abc	75.5abcd
25 (3)	323.3abc	72.7abcd
50 (1)	254.0bcd	57.5bcde
50 (2)	336.7ab	80.5abcd
50 (3)	297.3abcd	109.5a
75 (1)	227.3d	49.5de
75 (2)	253.7bcd	53.5cde
75 (3)	247.7cd	49.2de
100 (1)	53.3f	20.6f
100 (1)	76.7f	12.4f
100 (1)	150.7e	24.8ef

*Means followed by the same letter are not significantly different at the 0.5 level according to Duncan's new multiple range test.
†All treatments are with removal of shoot tips except the control.
‡(1) = Treatments applied at anthesis.
(2) = Treatments applied at first harvest.
(3) = Treatments applied at third harvest.

pistillate to staminate flowering nodes occurred between treatments. It was observed, however, that secondary laterals had a higher ratio of pistillate to staminate flowering nodes than did primary laterals and main stems. An increased number of secondary laterals following treatment may have resulted in an increase in the number of pistillate flowers on a plant. Insufficient growth took place on these lateral branches, however, for there to be a subsequent increase in yield.

Total fruit numbers for all treatments and treatment times showed no significant differences between the control, shoot tip removal alone, and 25% defoliation (Table 2). Fifty percent (50%) defoliation at first and third harvest also did not result in significantly reduced fruit numbers. Fifty percent (50%) defoliation at anthesis was significantly lower in fruit numbers, however.

Fruit numbers for the 75 and 100% defoliation treatments were significantly less than the control, with 100% defoliation significantly less than all other treatments. Rapid vegetative recovery for these treatments appeared to be at the expense of fruit set. There was less mean separation for fruit weight, but significance compared to the controls was similar to that for fruit numbers in most cases.

Up to 50% defoliation can occur without causing any appreciable loss of yield. Therefore, slight injury to the pickle vines can be tolerated without resulting economic loss.

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